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**BATTERY SAVING FLASH CHARGER CONTROL**

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## **BATTERY SAVING FLASH CHARGER CONTROL**

### **FIELD OF THE INVENTION**

The present invention relates to a photographic flash circuit, and,  
5 more particularly to a flash circuit having a voltage boosting circuit for charging a photoflash capacitor.

### **BACKGROUND OF THE INVENTION**

It is well known to use electronic flash circuits to provide artificial illumination of a scene to improve the appearance of a photographic image.  
10 Because cameras are typically portable many electronic flash circuits draw energy from portable batteries such as chemical batteries. Charging circuits are used to convert battery voltage into a higher voltage that can charge a flash capacitor so that it stores sufficient energy to cause a flash tube to discharge enough light to illuminate the scene. Chemical batteries provide a fixed amount of power to such  
15 flash circuits and, therefore, needless operation of the flash charging circuit is to be avoided to prevent premature exhaustion of the chemical batteries during a photography session.

U.S. Pat No. 4,522,479 entitled "Flash Apparatus with Power Supply Control Device" filed in the name of Yamada et al. on December 24, 1983  
20 discloses a power supply control device for use in a flash apparatus. The disclosed power supply control device automatically cuts off power to a flash apparatus by turning off a power switch at a predetermined time after the power switch is turned "on". This prevents the waste of electrical energy that can arise from, for example, the careless failure to turn the power switch off. The power supply  
25 control device is provided with a timer circuit that sets the predetermined period of time and is arbitrarily resettable with a manually operable power switch. The circuit of the '479 patent incorporates a number of expensive electrical components, including integrated circuits such as operational amplifiers and a one shot multivibrator. This makes such a circuit expensive. This circuit may be  
30 useful for flash circuits of the type that are incorporated in expensive products such as single lens reflex cameras and separable flash units of the type that are

typically used with SLR type cameras. What is needed is a less expensive circuit for use in lower cost cameras and one-time use cameras.

### SUMMARY OF THE INVENTION

A flash circuit for use in a camera, the flash charging circuit  
5 comprising a flash light discharge circuit having a light emitting element  
electrically connected to a flash capacitor; a flash triggering circuit connected to  
the flash light discharge circuit with the flash triggering circuit having a trigger  
signal generating circuit generating a signal that enables energy from the energy  
storage device to be converted into light by the light emitting element; a voltage  
10 conversion circuit connected between a battery and the flash capacitor to convert  
energy from a source voltage into a higher voltage to charge the flash capacitor; a  
timer circuit to cause the voltage conversion circuit to operate when the voltage at  
a timing capacitor is within a range of voltages, said timer circuit incorporating  
said timing capacitor in a time constant circuit that discharges energy stored in the  
15 timing capacitor at a predetermined rate; a reset circuit that resets the timing  
capacitor voltage to a voltage that is within the range; wherein the range of  
voltages is higher than the battery voltage and wherein the reset circuit first  
applies battery voltage to the timing capacitor and then applies voltage generated  
by the voltage conversion circuit to charge the timing capacitor to a voltage that is  
20 higher than the battery voltage.

A flash charging circuit for use in a camera, the flash charging  
circuit comprising a flash light discharge circuit comprising a light emitting  
element electrically connected to a flash capacitor; a flash triggering circuit  
connected to the flash light discharge circuit with the flash triggering circuit  
25 having a trigger signal generating circuit generating a signal that enables energy  
from the flash capacitor to be converted into light by the light emitting element;  
a voltage conversion circuit connected between a battery and the flash  
capacitor to convert energy from a battery voltage into a higher voltage to charge  
the flash capacitor; a timer circuit to cause the voltage conversion circuit to  
30 operate when the voltage at a timing capacitor is within a range of voltages, said  
timer circuit incorporating the timing capacitor in a time constant circuit that

discharges energy stored in the timing capacitor at a predetermined rate; and a reset circuit having a thyristor connected to the timing capacitor, a gate of said thyristor being triggered upon operation of a shutter of the camera, with the thyristor being connected to the battery and conducting energy from the battery to the timing capacitor when the thyristor is triggered to charge the timing capacitor to a voltage no greater than the battery voltage but within the range of voltages; wherein said voltage conversion circuit further supplies voltage pulses to the thyristor to charge the timing capacitor to a voltage higher than the battery voltage when the voltage conversion circuit is operated and wherein the thyristor turns off when the voltage at the timing capacitor approaches the voltage of said pulses.

In yet another aspect of the invention, what is provided is a photographic flash circuit. The flash circuit has a light emitting element connected to a flash capacitor, a flash triggering circuit which causes the light emitting element to convert energy from the flash capacitor into light and a voltage conversion circuit for converting a low battery voltage into a higher voltage to charge said flash capacitor, with the voltage conversion circuit having an oscillation transistor and at least one other transistor in an oscillation current path, said oscillation transistor oscillating during voltage conversion. A diode is connected to more than one transistor to suppress any voltage spikes at both transistors that appear during oscillation at the transistors to which the diode is connected.

In still another aspect of the invention a photographic flash charging circuit is provided. The photographic flash circuit comprises a light emitting element connected to a flash capacitor, a flash triggering circuit which causes the light emitting element to convert energy from the energy storage capacitor into light, and a timer control circuit adapted to cause the voltage conversion circuit to operate for a timing period and then automatically shut off, with the timer control being reset to the beginning of the timing period by actuation of the flash triggering circuit, with the timer control circuit having a timing period determined as a function of the voltage to which a timing capacitor is charged when the timer control circuit is reset. Test points are provided across

the timing capacitor so that a testing circuit can determine conditions at the timing capacitor during the testing.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

Fig. 1 shows one embodiment of a flash circuit in accordance with  
5 the present invention.

Fig. 2 shows another embodiment of a flash circuit in accordance with of the present invention.

Fig. 3 shows still another embodiment of a flash circuit in accordance with present invention.

10 Fig. 4 shows still another embodiment of a flash circuit in accordance with present invention.

### **DETAILED DESCRIPTION OF THE INVENTION**

Fig. 1 shows one embodiment of a flash circuit 10 in accordance with present invention. Flash circuit 10 is low-cost and therefore is particularly  
15 useful in a low-cost one time use camera. Flash circuit 10 comprises a voltage boosting circuit 12, a timer circuit 14, a reset circuit 16, a flash discharge circuit 18, and flash triggering circuit 22.

Voltage boosting circuit 12 comprises an oscillation step-up transformer 24 having a core 25, a primary winding 26 a secondary winding 28,  
20 and a feedback winding 30. Voltage boosting circuit 12 also has an oscillation transistor 32, a control switch transistor 34, a feedback current limiting resistor 38, a high-voltage rectifier diode 40, a resistor 41 and a light emitting diode 42. A battery 45 is also provided, and in the embodiment shown in Fig. 1, battery 45 comprises a single 1.5 volt battery. Battery 45 can take any variety of forms, for  
25 example, batteries of different size and/or voltage rating can be used as well as combinations of more than one battery.

Timer circuit 14 comprises a timing capacitor 44, time constant resistors 46, 48, and transistor 50.

Reset circuit 16 comprises latch transistors 54 and 56, connected to  
30 latch each other on, momentary contact switch 58, holding capacitor 60 and series

resistor 62 and flash sync detecting diode 64. In the embodiment shown in Fig. 1 reset circuit 16 also comprises resistors 80, 90, 92 and 98.

Discharge circuit 18 includes a flash capacitor 20 electrically connected to a flash tube 66. Flash tube 66 conducts electrical energy provided by flash capacitor 20 when a preferred potential exists at an electrode 68 on flash tube 66. Electrical energy is stored in flash capacitor 20 by voltage boosting circuit 12 in a manner that will be described in greater detail below.

Flash triggering circuit 22 comprises flash trigger transformer 70, a trigger capacitor 72, trigger capacitor charging resistor 74, and a flash sync switch 76. Flash triggering circuit 22 provides the preferred potential at electrode 68 in response to closure of flash sync switch 76 so that closure of flash sync switch 76 causes a flash of light to be discharged from flash tube 66 when flash capacitor 20 is appropriately charged.

The following sections will now describe the operation of the embodiment of Fig. 1. In the embodiment shown in Fig. 1, a charging cycle begins when the momentary contact switch 58 is closed. The closure of switch 58 creates a current that passes through a current limiting resistor 80 to create a voltage that forward biases latch transistor 56. This initiates a timing period during which timing capacitor 44 is charged. Latch transistor 54 and latch transistor 56 are connected to one another, collector to base, such that turning "on" one transistor of the pair will turn "on" the other and latch transistors 54 and 56 will keep each other forward biased as long as current is supplied to the emitter of latch transistor 54. This behavior is similar to a thyristor. In an alternative embodiment, a thyristor can be used in place of latch transistors 54 and 56.

Two sequential events take place after momentary contact switch 58 is momentarily closed. The first is that latch transistor 54 and latch transistor 56 turn "on". This allows timing capacitor 44 to charge to battery voltage minus the voltage drop of latch transistors 54 and 56. The second event begins when timing capacitor 44 is charged sufficiently to forward bias transistor 50, as control switch transistor 34 and oscillation transistor 32 turn "on", causing current to flow from battery 45 through primary winding 26 of step up transformer 24. Under this

“second event” condition, an oscillation cycle will begin. At this point, all transistors 32, 34, 50, 54, and 56 are turned “on.”

The following is a description of one oscillation cycle. Each oscillation cycle begins with current flowing through oscillation transistor 32 and  
5 primary winding 26 of step up transformer 24. The amount of current flowing in this way increases at a rate determined by the inductance of primary winding 26 and causes a corresponding increase in the magnetic flux in a core 25 of step up transformer 24. A corresponding current is induced in secondary winding 28 and feedback winding 30. The secondary voltage is stepped up to a high voltage and  
10 rectified by diode 40 to charge flash capacitor 20. When core 25 is saturated, current drops in the secondary winding 28 and feedback winding 30. A relatively low voltage positive flyback pulse is generated at the collector of oscillation transistor 32 as the flux in step-up transformer 26 collapses. This is the end of one oscillation cycle.

15 Negative voltage pulses are simultaneously generated at the emitter of control switch transistor 34 and at the base of oscillation transistor 32. A clamp diode 84 clamps these negative pulses, protecting both oscillation transistor 32 and control switch transistor 34 from damage due to excessive reverse bias. The use of a single diode, clamp diode 84, to protect both transistors is one factor that  
20 enables flash circuit 10 to provide protection for oscillation transistor 32 and control switch transistor 34 at a low cost.

The oscillator feedback used to drive the base of oscillation transistor 32 has two components. The first component is from transformer feedback winding 30. This signal is current limited by current limiting resistor 38  
25 and its magnitude is relatively constant for the duration of the time required to charge flash capacitor 20. The second component of the oscillation feedback is the flash capacitor charging current from the negative terminal of flash capacitor 20. This current is high when charging begins on a discharged flash capacitor 20. This current then decreases exponentially as flash capacitor 20 charges. These  
30 two currents are added together at the emitter of control switch transistor 34.

By itself, first component of the oscillator feedback will sustain oscillations at a minimum battery current, will keep flash capacitor 20 at full charge and will illuminate light emitting diode (LED) 42. However, both the first and second components are required to charge flash capacitor 20 to a requisite voltage to enable desirable flash discharge. This method of driving the base of oscillation transistor 32 has the advantage of using less energy from battery 45 after the flash capacitor 20 is charged, because oscillation is sustained only to maintain the flash capacitor 20 at flash ready voltage and to illuminate the LED 42.

The reverse voltage amplitude of the oscillation pulses on feedback winding 30 are proportional to the voltage on flash capacitor 20. The number of turns in feedback winding 30 is chosen so that the reverse oscillation pulse voltage will begin to illuminate LED 42 when flash capacitor 20 is charged to flash ready voltage. This flash ready voltage can be, for example, about 300 volts. Thus, LED 42 indicates to the photographer when flash circuit 10 is ready to take a flash picture.

During the first event (previously described), the emitter of latch transistor 54 and the collector of oscillation transistor 32 are at a voltage established by the voltage at battery 45. The second event is defined when a series of oscillations begins at oscillation transistor 32. Transistor 32 begins to oscillate when the magnetic field in core 25 of step up transformer 24 saturates and collapses inducing a periodic pulse signal known as a flyback signal in secondary winding 28 and feedback winding 30. The flyback signal is present during half of the oscillation cycle and takes the form of pulses at the collector of oscillation transistor 32 and at the emitter of latch transistor 54. During the other half of the oscillation cycle the collector of oscillation transistor 32 and the emitter of latch transistor 54 are at the saturation voltage of oscillation transistor 32. The saturation voltage is substantially less than the base-emitter voltage drop of transistor 32.

Latch transistors 54 and 56 are forward biased by the flyback pulses and transfer energy from the flyback pulses to charge timing capacitor 44.



Transistors 54 and 56 turn off in between successive flyback pulses because the voltage at the emitter of transistor 54 (the saturation voltage of transistor 32) is less than the voltage on timing capacitor 44.

Timing capacitor 44 is eventually charged to the voltage of the  
5 flyback pulses minus the combined voltage drops of latch transistors 54 and 56. At this point the current through transistors 54 and 56 approaches zero and the transistors turn off, leaving timing capacitor 44 charged.

The time duration that latch transistors 54 and 56 conduct flyback  
pulses is a function of flyback pulse amplitude, frequency and harmonics which  
10 may be present on the flyback pulses. To reduce the influence of these factors, holding capacitor 60 and resistor 62 can be connected across the base-emitter of transistor 54. Holding capacitor 60 maintains transistors 54 and 56 “on” in-between flyback pulses.

As the collector current approaches zero, the current from holding  
15 capacitor 60 to the base of transistor 54 also drops, this current being supplied from the collector of transistor 56. When capacitor 60 is discharged, latch transistors 54 and 56 turn off, leaving timing capacitor 44 charged. Resistor 62 controls the discharge rate of holding capacitor 60. This establishes the time that transistors 54 and 56 are held “on”. This improves the repeatability of the  
20 charging time of timing capacitor 44, which is otherwise dependent on flyback pulse amplitude (which is a function of battery energy level), frequency and harmonics present on the flyback pulses.

Resistors 90 and 92 insure that transistors 54 and 56 will stay off in the absence of forward bias. Resistor 100 insures that control switch transistor 34  
25 will stay off in the absence of forward bias. Resistor 102 limits the current to the base of control switch transistor 34. Resistor 48 provides a slow discharge path for timing capacitor 44 and resistor 46 provides a trickle bias for timing transistor 50, which stays “on” until the charge on timing capacitor 44 falls below the forward base to emitter bias of timing transistor 50. When this occurs, transistor  
30 50 turns “off”, which in turn turns “off” control switch transistor 34 and

oscillation transistor 32. This ends the timing period. As transistors 54 and 56 have previously turned off, all of transistors 32, 34, 50, 54, and 56 are “off”.

Typically batteries of the type used as battery 45 in a flash circuit 10 are less efficient at low temperature. Therefore the amount of time that is  
5 required to charge flash capacitor 20 will be longer at low temperature. It may therefore be desirable to provide features in flash circuit 10 that automatically provide a longer timing period when flash circuit 10 is operated in low temperature environments. Accordingly, in one embodiment of the present invention, resistor 48 is a temperature dependent resistor, such as a thermistor or  
10 other temperature dependent variable resistor. This embodiment of resistor 48 is selected so that the resistance provided by resistor 48 increases as ambient temperature decreases. This, in turn provides a longer timing period when this embodiment of flash charging circuit 10 is operated at a low temperature and a shorter timing period at normal temperatures.

15 Switch 76 comprises shutter sync contacts 94 and 96, which close when a shutter (not shown) in a camera (not shown) that uses flash circuit 10 opens to expose a film (not shown) in the camera. When this occurs, trigger capacitor 72 is charged to the flash capacitor voltage through resistor 74. When sync switch 76 closes, trigger capacitor 72 discharges into the primary winding of  
20 trigger transformer 70, generating a very high voltage pulse at a secondary winding of trigger transformer 70, which is applied to contact 68 and which provides sufficient potential to initiate conduction in flash tube 66. Flash capacitor 20 then discharges through flash tube 66, which emits light. The timing period comprises both the charging and discharging of timing capacitor 44.

25 The timing period is automatically restarted when sync switch 76 is closed. Diode 64 is normally reverse biased by the high voltage charge on capacitor 20. The minimum voltage on flash capacitor 20 will be the voltage at battery 45 minus the forward voltage drop of rectifier diode 40. This minimum voltage is sufficient to reverse bias flash sync detecting diode 64.

30 When sync switch 26 closes, flash sync detecting diode 64 is forward biased and current flows through a current limiting resistor 98 to turn

“on” latch transistor 54. This begins the automatic timing period reset after flash by initiating the first sequential event described above. However, it will be appreciated that the closure time of sync switch 76 is about 0.1 millisecond, which is much shorter than a closure time that can be provided by a person pressing  
5 momentary switch 58 to initiate charging. The closure time of sync switch 76 is also shorter than the time required for flyback pulses to appear at the emitter of latch transistor 54 and is thus shorter than the time required to complete the first sequential event. This problem is solved in reset circuit 16 by transistors 54 and 56, which are kept “on” by the bias from holding capacitor 60 which is charged  
10 during the conduction of flash sync detecting diode 64, thus insuring completion of the first sequential event.

Fig. 2 shows another embodiment of flash circuit 10 of Fig. 1. In this embodiment flash circuit 10 has a filtering capacitor 110 connected across the base-emitter of latch transistor 54 and a filtering capacitor 112 across the base-  
15 emitter of latch transistor 56. Small amplitude impulse noise or static electricity can trigger these transistors “on” and initiate an undesired timing period. Filtering capacitors 110 and 112 reduce the sensitivity of flash circuit 10 to impulse noise without substantially increasing the cost of this embodiment of flash circuit 10.

Fig. 3 shows another embodiment of a flash circuit 10. In the  
20 embodiment of Fig. 3 a charge limiting circuit 114 is added to the embodiment shown in Fig. 1 to further improve the battery efficiency of flash circuit 10. As described above, in flash circuit 10 the oscillator feedback signal to the base of oscillation transistor 32 has two components. The first component is from transformer feedback winding 30. The second component is the flash capacitor  
25 charging current from the negative terminal of flash capacitor 20. These two currents are added together through the emitter of control switch transistor 34. The first component alone will sustain oscillations after flash capacitor 20 is charged but both current components are necessary to drive oscillation transistor 34 sufficiently to charge flash capacitor 20.

30 In the embodiment of Fig. 3, additional battery energy savings are obtained by electronically disconnecting the flash capacitor 20 from charging

circuit 12 after flash capacitor 20 reaches a voltage determined by a zener diode 120 which can establish a voltage limit of, for example, 320 volts. This is done by disconnecting the second current component from the emitter of oscillation transistor 32 and allowing the first current component to sustain oscillations, at  
5 minimum battery current, for the duration of the timing period. This prevents the charger from using battery energy to charge flash capacitor 20 to a voltage higher than necessary. Even though flash capacitor 20 charging is terminated, ready light LED 42 is illuminated for the duration of the timing period.

While flash capacitor 20 is charging, transistor 122 is biased "on"  
10 by resistor 124 and transistor 126 is not conducting. Transistor 122 thus conducts the charging current from a negative terminal of flash capacitor 20 to the emitter of control switch transistor 34, providing normal flash capacitor charging. Zener diode 120 conducts at flash ready voltage and forward biases transistor 126, which is normally biased "off" by resistor 128. Resistor 130 limits the current to the base  
15 of transistor 126. When transistor 126 turns "on" it biases transistor 122 "off", which effectively disconnects the negative terminal of flash capacitor 20 from the emitter of control switch transistor 34. The oscillation of oscillation transistor 32 is sustained only by current from feedback winding 30 and ready light LED 42 is illuminated. The battery current is minimum because flash capacitor 20 is not  
20 being charged.

As the flash capacitor discharges, zener diode 120 will cease conduction and transistors 122 and 124 will reconnect flash capacitor 20, which will recharge to the zener voltage. This cycle will repeat until the timing period ends, maintaining the flash capacitor at the zener voltage while conserving battery  
25 energy. Therefore the embodiment of Fig. 3 always charges flash capacitor 20 to the same voltage, a voltage established by zener diode 120, with either a strong or weak battery.

Fig. 4 shows still another alternative embodiment of the circuit of Fig. 1. In this embodiment holding capacitor 60 and series resistor 62 are omitted.  
30 In this configuration transistors 54 and 56 operate to recharge the timing capacitor 44 and thus reset the timing period. Transistors 54 and 56 both turn "on" for each

flyback pulse and turn “off” when each flyback pulse terminates. Latch transistors 54 and 56 cease turning “on” when timing capacitor 44 charges to the amplitude of the flyback pulses because of the diminished voltage drop across latch transistors 54 and 56. This ends the reset period for timing capacitor 44 and  
5 timing capacitor 44 will begin discharging.

As is also shown in Fig. 4, optional test points 132 and 134 are provided across timing capacitor 44 so that a testing circuit from a testing circuit (not shown) can determine conditions at the timing capacitor. Depending on the testing regimen applied, the testing circuit (not shown) can determine the  
10 condition at the timing capacitor by measuring the voltage on timing capacitor 44, also the testing circuit can modify the state of timing capacitor 44 by changing the time constant associated with timing capacitor 44 or by shorting the timing capacitor 44 to prematurely terminate the timing period. Also the testing circuit (not shown) can force timing capacitor 44 to a predetermined voltage to quickly  
15 move the timing period to a certain state.

The invention has been described in detail with particular reference to certain preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

**PARTS LIST**

10	flash circuit
12	voltage boosting circuit
14	timer circuit
16	reset circuit
18	flash discharge circuit
20	flash capacitor
22	flash triggering circuit
24	step up transformer
25	core of step up transformer
26	primary winding
28	secondary winding
30	feedback winding
32	oscillation transistor
34	control switch transistor
38	limiting resistor
40	voltage rectifier diode
41	resistor
42	light emitting diode
44	timing capacitor
46	current limiting resistor
45	battery
48	time constant resistor
50	timing transistor
54	latch transistor
56	latch transistor
58	momentary contact switch
60	holding capacitor
62	series resistor
64	flash sync detecting diode
66	flash tube

70	flash trigger transformer
72	trigger capacitor
74	trigger capacitor charging resistor
76	flash sync switch
80	current limiting resistor
84	clamp diode
90	resistor
92	resistor
94	flash sync switch contact
96	flash sync switch contact
98	current limiting resistor
100	resistor
102	resistor
110	filtering capacitor
112	filtering capacitor
114	charge limiting circuit
120	zener diode
122	transistor
124	resistor
126	transistor
128	resistor
130	current limiting resistor
132	test point
134	test point